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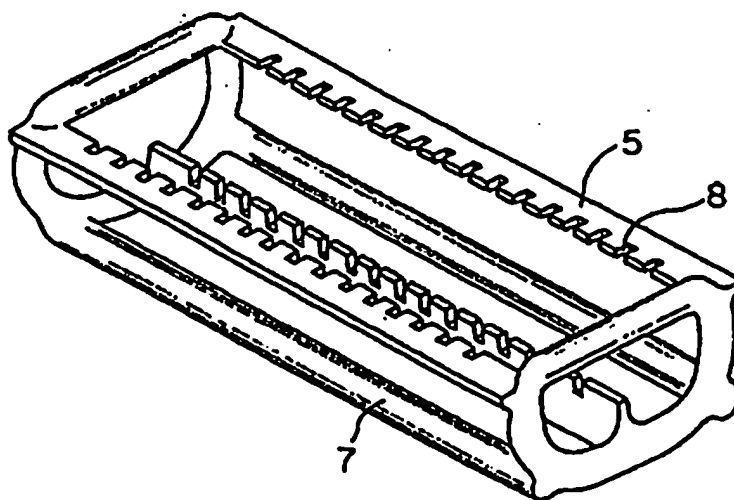
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(54) Title: QUARTZ GLASS JIG FOR THE HEAT TREATMENT OF SILICON WAFERS AND METHOD AND DEVICE FOR PRODUCING SAME

(57) Abstract

A quartz glass jig for heat-treating semiconductor devices comprising silicon wafer resting members having quartz glass boards in and along which wafer resting positions formed by laser beam machining. No microcrack on the wafer resting members of a quartz glass jig for heat treating silicon semiconductor devices occurs and contamination by impurities is prevented and thus favorable heat treatment of the silicon semiconductor devices is performed when the jig is used. A combinational jig for heat treatment of silicon wafers comprises a resting member and a base member for supporting the resting member. Both resting member and base member are made of quartz glass and combined together via a silicon member. Also, a method of fabricating the combinational jig is disclosed. The novel combinational jig for heat treatment of silicon wafers can effectively prevent contamination of silicon wafers, especially contamination due to movement of sodium element, and thus the combinational jig provides high-quality silicon wafers.



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## **QUARTZ GLASS JIG FOR THE HEAT TREATMENT OF SILICON WAFERS AND METHOD AND DEVICE FOR PRODUCING SAME**

### **Industrial Field of Application**

The present invention relates to a quartz glass jig for heat treatment of silicon wafers comprising a silicon wafer resting member, having a quartz glass board in and along which wafer resting grooves are formed, a method of producing the same and to an annealing furnace for realization of the method.

Furthermore the invention relates to a quartz glass jig for heat treatment of silicon wafers, comprising a resting member on which the silicon wafers are placed and a base member for supporting the resting member. In the following such a jig will be named combinational jig.

### **Prior Art**

Quartz glass has been used as a jig for heat-treating silicon semiconductor devices because it is higher in purity as compared with other refractory materials and coalescence by welding is possible.

The recent increase in the packing density of a semiconductor device and the appearance of newly developed devices in which an impurity is extremely intolerable such as flash memory require further purified quartz glass.

Under such circumstances in order to meet the requirement, high purity natural quartz crystal

powders, synthesized quartz glass powders and the like have been developed and are available.

Particularly as to synthesized quartz glass powders, the extremely highly pure powders of 0.1 ppm or less in the total concentration of metal impurities are now available in an industrial scale.

A conventional quartz glass jig for heat-treating semiconductor jig is produced, in sequence, in the following steps of:

extruding a round rod of each of the aforementioned high purity materials from a round nozzle such as disclosed in British Patent Publication No.400,472;

fixing each round rod with wax 14 on an iron surface plate 13 as shown in FIG.5;

cutting wafer resting grooves along the round rod with a rotating diamond blade 15 to fabricate a silicon wafer resting member; and

welding a supporting member constructed from the round rods integrally with the wafer resting members using oxygen-hydrogen flame as a heat source.

Automation of loading silicon wafers and transferring a jig into a heat-treatment furnace have been practicable, because dimensional precision can be achieved in such machining as above-mentioned.

Microcracks occur due to brittleness in the surface region of quartz glass up to a depth of sometimes more than 100  $\mu\text{m}$ , when cutting is carried out on the surface.

Such impurities as Na, K, Li, Ca, Cu, Fe, Ni and the like which are originated from tools and a coolant are incorporated into the microcracks. Therefore there was a problem that silicon wafers were contaminated when they were heat-treated. In this state, if the surface region of more than 100  $\mu\text{m}$  in depth is etched off in a cleaning operation, the newly exposed surface region can become pure, but that with an adverse effect of a sacrificed dimensional precision of the surface.

There are chances in some actual cases that the dimensional precision and purity level of the surface are not compatible with each other. Particularly, when machining with a dimensional precision of  $\pm 5/100$  ( mm ) is intended that is required for automatic silicon wafer loading, both of occurrence of microcracks and incorporation of impurities have been almost unavoidable at the same time.

To avoid contamination of silicon wafers during heat treatment high-purity quartz glass jigs are used. Accordingly, in an attempt to fabricate jigs of higher purity, better techniques for refining quartz stock have been developed. Also, techniques for fabricating high-purity synthetic quartz glasses from high-purity industrial chemicals have been developed. Especially, for the synthetic quartz glasses, it is possible to industrially produce those synthetic quartz glasses which have extremely high degrees of purity (i.e., the total amount of metal impurities is not in excess of 0.1 ppm). Moreover, it has been possible to implant several ppm desired additive without mixing other impurities (e.g., 1 ppm aluminum is added) to impart heat resistance to such quartz glasses. However, if a jig is fabricated from such high-purity quartz glass, and if silicon wafers are heat-treated in a high-purity ambient, then it is difficult to avoid contamination due to alkali elements, especially sodium. Consequently, it has been impossible to overcome the disadvantage that high-grade devices are manufactured at low yield.

Furthermore it has been found that sodium contamination of wafers is not directly caused by the ambient gas but attributed to contamination of the jig on which the wafers are placed. The contamination of the wafer resting member is not limited to the period for which the silicon wafers are being thermally processed but starts already during annealing of quartz glass fabricated by glass blowing. If a sodium contamination source such as heat-insulating material around a heat-treatment furnace is coupled to wafers via a quartz glass base member to thereby form a direct contact path, then sodium contaminates the wafers.

#### **Problems to be Solved by the Invention**

In light of the present state of the art, it is accordingly an object of the present invention to provide a quartz glass jig for heat-treating semiconductor devices having a dimensional precision and surface cleanliness so that the silicon wafers resting on the resting grooves are not contaminated.

Furthermore, the present invention is intended to provide a jig for heat treatment of silicon wafers, the jig being characterized in that the silicon wafers are not contaminated.

It is a further object of the invention to provide a method of fabricating a jig for heat treatment of silicon wafers.

It is a further object of the invention to provide an annealing furnace for fabricating a jig for heat treatment of silicon wafers.

### Means to Solve the Problem

The present inventor has been making efforts on a study and as a result discovered the fact that a quartz glass jig for heat-treating semiconductor devices without the faults above-mentioned was obtainable by application of laser beam machining to formation of silicon wafer resting grooves of a quartz glass jig for heat-treating silicon semiconductor devices.

Furthermore it has been found that if a silicon member is inserted between the wafer resting member and the base member, the contamination path is blocked and then the contamination is shut off at this point, and that the wafer resting member above this shutoff point is maintained at a high purity.

The quartz glass jig for heat-treating silicon wafers comprises as shown in FIG.2 silicon wafer resting members 5 and a supporting member 7 for supporting the wafer resting members 5, where wafer resting positions 8 such as grooves or teeth are provided for the respective wafer resting members 5.

The silicon wafers 6 are loaded in this jig and transferred into a electric furnace for heating the wafers 6 at a temperature around 1000 °C and at the same time for forming an oxide film on the surface each.

In the above treatment, when such impurities as Na, K and other alkali elements, Fe, Ni and Ca are present in the surface region of the quartz glass, the impurities are released out and the silicon wafers are contaminated.

The surface region of a depth up to 30  $\mu\text{m}$  of quartz glass forming a jig should therefore have such a purity level that concentrations of Na, K, Fe and Ca are respectively 0.4 ppm or less, 0.2 ppm or less, 0.4 ppm or less, and 0.8 ppm or less.

In order to achieve this purity level, according to the present invention, raw material having the above-mentioned purity level is used and an extrusion molding method is applied to such raw material to produce each part of the jig.

It is not preferable and to be avoided that each board for a wafer resting member is molded excessively thick and later thinned by grinding or the like to adjust the thickness and in another

case boards are sliced from a large block, since these kinds of processing cause microcracks in the surface. Such mechanical processing is also undesirable because metal powders that are a cooling agent for a diamond tool have chances to adhere the quartz glass surface. Each part of a quartz glass jig is preferably molded by extrusion into dimensions close to the predetermined, where molding by extrusion does not mean only a method that a molten substance is extruded under pressure through an opening.

For example, methods are included in the sense of molding by extrusion that boards as formed are further extended out through feed rollers and in another case feed rollers generating an torque working in such a manner as to move up a board are used so as to prevent the board from free fall under the gravity and thereby the board is descending at a constant speed. Further, included in this sense are a method to pull up a board upward, a method to extend it sideways and the other variations. All these variations are applicable to the present invention as far as the board is formed directly by molding and cutting or grinding is not necessary in a following step.

A silicon wafer resting member 5 is fabricated from a quartz glass board, since the wafer resting member is hard to be processed by laser beam machining from starting materials not uniform in thickness.

When starting from a quartz glass board, a processing high in dimensional precision is realized by laser beam machining as shown in FIG.1 and automatic loading of wafers and automatic transfer of a jig is thus made possible.

As to methods of producing a quartz glass board, it will be enough if a method disclosed in a publication of Unexamined Japanese Patent Application No.4-55332 and a method disclosed in a Japanese publication of PCT Patent Application No.94/3404 are used. All has to do is to adopt a most applicable method in consideration both of a design of a jig and of the number of the jigs to be produced.

It is preferable to construct a supporting member for supporting silicon wafer resting members with round rods in terms of working efficiency. The round rods are welded to form a jig such as silicon wafer boat as shown in FIG.2, where a numeral 5 indicates silicon wafer resting members, a numeral 7 indicates a supporting member and a numeral 8 indicates grooves for resting wafers.

Laser beam machining as shown in FIG.1 is best applied to formation of the grooves 8, where a quartz glass board 2 is placed on a working table for laser beam machining to cut grooves 8 for resting the wafers, where the CO<sub>2</sub> gas laser 1 is displaced by supporting arms 3 on rails. During laser beam machining, Ar assist gas 4 is blown into a groove 8 under cutting so as not to have a fume remain in the groove 8. The output power of laser beam for cutting is so adjusted as to obtain a smooth surface. The cutting of a dimensional precision of  $\pm 0.05$  mm is executable, if position control in the cutting process is made by the unit of 1  $\mu$ m. Some of the fume has a chance to remain in the neighborhood of the cutting surface in such a degree as to have a faint change of the color, even if the Ar assist gas is blown. Therefore, the color-changed portion is etched off by dipping in a diluted hydrofluoric acid. No crack occurs and the surface is smoothed, by adopting laser beam machining.

In laser beam machining, cutting a groove on a round rod is hard due to lack of uniformity in the depths to be cut around the rod surface. Boards as molded by extrusion have a thickness variation of  $\pm$  at most about 0.3 mm and this variation does not adversely affect the uniformity of processing in laser beam machining. Boards as molded by extrusion is therefore preferably used in the present invention.

The coverage of laser beam machining on the surface in the neighborhood of a wafer resting position is enough if it is conducted throughout the surface portion within 2 cm of the contact point with the silicon wafer inserted. With no laser beam machining beyond the surface portion, contamination of silicon wafers does not occur, even though diamond processing is applied there.

As mentioned above the improvement concerning combinational jigs is characterized in that the wafer resting member and the base member are made of quartz glass and combined together via a silicon member.

The inventive combinational jig the silicon member inserted between both member prevents them from contacting each other. Where a horizontal heat treatment furnace is used, if the wafer resting member takes the form of a cassette boat, and if the base member assumes the form of a mother boat, then they can be easily and conveniently handled. Where a vertical heat treatment furnace is employed, it may be reasonable to consider that a bottom cover which acts to prevent thermal energy from escaping is the novel base member, the bottom cover being located under placement bases and under the furnace. A wafer boat is placed on these bases.



The wafer resting member is provided with grooves, claws, and so on to permit placement of silicon wafers. A plurality of silicon wafers are placed on this wafer resting member. This wafer resting member is placed over the base member via the silicon member. These are moved into the furnace tube in an electric furnace. They are heated to a high temperature of about 1000 °C. In this way, the silicon wafers are oxidized or otherwise processed.

Research of the present inventor has revealed that lithium is normally released from all quartz glass jigs such as the above-described furnace tube placed inside the heating electric furnace and the wafer boat, and that all of these jigs absorb potassium and sodium. Of the absorbed elements, the rate at which the potassium is absorbed is low, i.e., more than 10 times as low as the rate at which sodium is absorbed. Therefore, sodium can be regarded as substantially immovable. Because the absorption rate of sodium is high and because it moves through quartz glass at a high speed, sodium contaminates silicon wafers and deteriorates the quality. The contamination route of the sodium does not go from the ambient gas surrounding the silicon wafers directly to the wafers but extends either through or along the solid with which they are in direct contact. For example, it was found that in the case of a horizontal furnace, sodium mainly goes through the direct contact route, comprising the electric furnace body, the liner tube, the quartz glass furnace tube, the quartz glass boat, and silicon wafers. If the wafer resting member is contaminated heavily with sodium, the hydrofluoric acid in the vessel for cleaning the jigs is contaminated, the clarity of the quartz glass is lost, and other harmful results arise. The present invention is intended to prevent contamination of the wafer resting member to a higher level, thus processing good-quality wafers.

The aforementioned movement of sodium can be shut off by placing a silicon member in the midpoint of the contamination route. Since the shutoff point is preferably located close to the wafers, the inventive combinational jig has the silicon member at the position where the wafer resting member is in contact with the base member. No limitations are imposed on the thickness of the silicon member as long as it can block movement of alkali elements. However, it is better to set the thickness within the range of from about 0.3 to 10 mm because of the mechanical strength and easiness of handling.

The quartz glass of the base member forming the novel combinational jig contains 5-20 ppm aluminum, less than 0.1 ppm lithium, and less than 0.1 ppm sodium, i.e., so-called low-alkali species quartz glass (all concentrations in weight-ppm). By using such quartz glass, sodium is captured before the shutoff point (on the opposite side of the wafers). In consequence, the

silicon wafers can be prevented from being contaminated. If the aluminum content in the quartz glass of the base member is below the above-described range, sodium is not sufficiently captured. If the range is exceeded, loss of clarity of the quartz glass tends to occur. If the sodium content exceeds the range described above, the sodium in the quartz glass approaches its saturated state. Consequently, sodium cannot be sufficiently captured. Experiments have shown that if the glass is heated at 1100 deg. C for 1000 hours in an annealing furnace, the glass approaches the saturation point. However, after the glass is annealed only for about 1 hour, it is assured that increase of sodium is observed by a high-sensitivity analysis. If the lithium content exceeds the aforementioned range, release of lithium contaminates the inside of the furnace, thus producing undesirable results.

The wafer resting member forming a quartz glass jig according to the present invention is formed from various high-purity quartz glasses containing less than 0.2 ppm iron. If the iron exceeds this range, the lifetime of carriers inside the wafers in contact with the iron is deteriorated, thus yielding undesirable results. It is to be noted that if the wafer resting member is not contaminated with sodium, it does not always follow that the wafers are prevented from being contaminated with sodium. It is necessary that the contamination route be shut off by the silicon member on the opposite side of the wafers on the wafer resting member. In numerous cases observed, if the silicon member is absent, a large amount of sodium passes through the wafer resting member and contaminates the wafers but the sodium content in the quartz glass of the jig hardly increases. The best are obtained with combinational jigs as described above and having wafer resting grooves which are formed by laser beam machining.

One example of a method of fabricating a combinational jig according to the invention is described next. A cassette boat that is a jig on which silicon wafers are placed is fabricated by glass blowing from various high-purity quartz glasses containing less than 0.2 ppm iron. Also, a mother board which is a base member is formed by glass blowing from a low-alkali quartz glass containing 5-20 ppm aluminum, less than 0.1 ppm lithium, and less than 0.1 ppm sodium. If necessary, grooves for insertion of wafers are machined in these jigs. Thermal strain is left in the quartz glass by machining using a burner during the glass blowing. Therefore, annealing is necessary to remove the strain. The annealing is performed in such a way that the jigs are placed inside the annealing furnace. This annealing furnace is designed so that a quartz glass block is placed on an aluminum board furnace floor board and that silicon bases are placed on the block. The jigs are placed on the silicon bases and annealed. This prevents the wafer

resting member from being contaminated with sodium. Furthermore, the ability of the base member to capture sodium can be maintained. It is not necessary that the silicon bases cover the whole surface of the furnace floor. Rather, the requirement placed on the size of the silicon bases is only that the annealed quartz glass jigs do not touch the furnace floor. Sufficient advantages can be had if one silicon base is placed at each one contact point.

In the novel quartz glass jigs, the cutoff point of the sodium contamination route is preferably located close to wafers and so the base member preferably accounts for at least 30 % by weight of the total weight of the jig assembly.

Since the novel combinational jig can process objects without contaminating them as mentioned previously, the combinational jig is adapted for the step of forming thin oxide film on silicon wafers. In addition, the combinational jig can also be used as a general wafer heat treatment jig.

Furthermore, the annealing furnace used for manufacture of the inventive combinational jig can be applied to fabrication of general quartz glass products which should be prevented from being contaminated with alkali elements.

Examples of the jig and of the method of the present invention will be described below in reference to the accompanying drawings.

#### **Brief Description of the Drawings**

- FIG. 1** is a schematic perspective view of a laser beam machine for processing wafer resting members of the present invention.
- FIG. 2** is a perspective view of a horizontal furnace quartz glass jig for heat treatment of the present invention.
- FIG. 3** is a schematic cross-sectional view of a production apparatus of round rods constructing a jig of the present invention.
- FIG. 4** is a schematic cross-sectional view of a production apparatus of boards constructing a jig of the present invention.

- FIG. 5** is a schematic view of a production apparatus of a conventional quartz glass jig for heat-treating semiconductor devices.
- FIG. 6** is a perspective view of the cassette board of a cassette mother board type horizontal combinational jig according to the present invention;
- FIG. 7** is a perspective view of the mother board of the cassette mother board type horizontal combinational jig according to the invention;
- FIG. 8** is a horizontal cross section of the cassette mother board type horizontal combinational jig according to the invention;
- FIG. 9** is a cross-sectional view taken on line A-A' of Fig. 8, and in which the cassette mother board type horizontal combinational jig according to the invention has been carried into a furnace tube;
- FIG. 10** is a schematic cross section of a vertical combinational jig according to the invention, the combinational jig being used for heat treatment of silicon wafers; and
- FIG. 11** is a schematic cross section of an annealing furnace according to the invention.

High purity quartz crystal powders 12 are supplied in an electric furnace 9 as shown in FIGS. 3 and 4, molten by heating.

The molten quartz is then extruded through the nozzle 10 to produce a quartz glass rod 11 or a quartz glass board 2.

Each of the thus produced quartz glass boards 2 is set in a laser beam machine as shown in FIG. 1, grooves for resting silicon wafers 8 are cut and then the machined quartz glass boards 2 and a supporting member 7 constructed from the quartz glass rods 11 are electrically welded with one another to complete a silicon wafer boat as shown in FIG. 2.

The method as described above relates to an example of the horizontal furnace boats, and a vertical furnace boat is also fabricatable forming grooves or teeth 8 for resting wafers by means of a similar method to that as mentioned above.

## Examp l s

### Example 1

Quartz crystal powders of raw material were treated by floatation and electromagnetic separation, washed in hydrofluoric acid and nitric acid and further refined with a mixed gas of chlorine and hydrogen chloride at 1100 °C. As a result, quartz crystal powders with such an impurity level as a concentration of Fe less than 0.05 ppm, a concentration of Na less than 0.05 ppm, a concentration of Ka less than 0.05 ppm and a concentration of Ca less than 0.5 ppm were obtained.

The thus treated quartz crystal powders were heated in a molybdenum crucible disposed in an electric furnace 9 at 2200 °C to be transformed to transparent quartz glass. The quartz glass was then molded with a extruder as shown in FIGS.3 and 4 into round rods 11 of 15 mm in diameter and boards 2 of 4 mm thick and 35 cm wide.

Grooves for resting wafers 8 were cut in and along some of the boards by means of a method of laser beam machining as shown in FIG.1 to complete wafer resting members 5 and next the wafer resting members 5 were welded to assemble a silicon wafer boat. The thus produced silicon wafer boat was washed in a hydrofluoric acid of 4.5 % in concentration for 3 minutes to remove the adhered fume and surface contamination.

The internal surface in each of the grooves for resting wafers 8 was smooth.

The impurities in the surface region up to 30 µm in depth of the jig, that is the silicon wafer boat, were measured after etching by hydrofluoric acid of the whole surface region and the results expressed on the average were as follows:

The concentration of Fe was less than 0.05 ppm, the concentration of Na was less than 0.05 ppm, the concentration of Ka was less than 0.05 ppm and the concentration of Ca was less than 0.5 ppm.

It is seen from the data that the purity level of the raw material was kept unchanged in the jig. Oxidation treatment on wafers was carried out using the wafer boat and as a result all the wafers had uniform oxide films of good quality.

### **C mparative Example 1**

Grooves for resting wafers 8 were cut in a conventional method for cutting by a diamond tool 15 as shown in FIG.5 to complete a wafer boat and the purity level in the surface region up to 30  $\mu$ m in depth of a wafer boat was analyzed in a way like the example as above-mentioned.

The results from the analysis were as follows: The concentration of Fe was 0.55 ppm, the concentration of Na was 0.50 ppm, the concentration of Ka was 0.35 ppm and the concentration of Ca was 1.2 ppm.

It is seen from the results that contamination occurred.

In the use of this wafer boat in oxidation treatment, this wafer boat was exposed to hydrogen chloride gas at a temperature of 1000 °C and a time of 20 hours, which treatment is a so-called "purification by high temperature gas," to thereby obtain a wafer having an oxide film of good quality.

### **Comparative Example 2**

A wafer boat produced in a similar way to that of the comparative example 1 was repeatedly treated in hydrofluoric acid to have been cleaned, while monitoring the surface purity level by the analyses of the etching solution.

In the second run of etching treatment, all the surfaces had been cleaned, but the boat was unable to be used as that for automatic loading, because the width of the opening of each of grooves was increased by more than about 0.1 mm and what's more a disorder in the shapes of the grooves was resulted.

### **Comparative Example 3**

A wafer boat was prepared in a similar way to that of the example except that one of the outmost ends of the grooves in a row is cut with a diamond cutter and wafers were loaded in the wafer boat to execute oxide-film formation treatment. The result were that the wafers positioned within 2 cm of the outmost groove were of poor quality due to an excessive thickness of the oxide film.

Specific examples of a novel combinational jig for heat treatment of silicon wafers are illustrated in Figs. 6-9.

## **Example 2**

### **Method of Fabricating Combinational Jig for Heat Treatment of Silicon Wafers**

Samples A-C consisting of powdered quartz listed in Table 1 were vitrified to create glasses. Using these glasses, quartz glass stocks Nos. 1-3 listed in Table 2 were created by an electric melting process. No. 4 was created from sample A of powdered quartz by an acid-hydrogen flame process.

Tabl 1

	Sample A	Sample B	Sample C
Al	5 ppm	5 ppm	15 ppm
Li	0.1 ppm	0.5 ppm	0.1 ppm
Na	0.05 ppm	0.05 ppm	0.05 ppm
K	0.1 ppm	0.2 ppm	0.1 ppm

Silicon wafer jigs and support jigs were created by glass blowing from raw materials consisting of the above-described quartz glass round rods. The jigs were annealed to remove the thermal strain in the jigs. In an annealing method according to the present invention, a quartz glass block 27 of 25 mm was laid on an alumina furnace floor board 27 shown in Fig. 11. Silicon bases 28 having a thickness of 5 mm were disposed in a furnace. In the prior art processing, a furnace in which the silicon bases 28 were not disposed was used. These two kinds of processing were conducted. Each jig was annealed until the strain was removed. Then, the jig was chemically analyzed. The results are listed in Table 2.



Table 2

	Al (ppm)			Li (ppm)			Na (ppm)			K (ppm)		
	round rod stock	prior art	novel	round rod stock	prior art	novel	round rod stock	prior art	novel	round rod stock	prior art	novel
No. 1	5	5	5	0.1	0.05	0.1	0.05	0.8	0.05	0.1	0.12	0.1
No. 2	5	5	5	0.5	0.05	0.5	0.05	0.80	.05	0.2	0.25	0.2
No. 3	15	15	15	0.1	0.05	0.1	0.05	1.2	0.05	0.05	0.06	0.05
No. 4	5	5	5	0.1	0.05	0.1	0.05	1.5	0.05	0.1	0.13	0.1

As can be seen from Table 2 above, the purity of the raw material of the jigs processed by the present invention (i.e., the quartz glass jigs were not in direct contact with the annealing furnace) was maintained substantially. The raw materials had high purity.

On the other hand, in the jigs processed by the prior art method, alkali elements, especially sodium element, increased greatly. These jigs could not be used as silicon wafer placement jigs.

#### **Example of Application to Heat Treatment of Wafers**

In Fig. 6, a silicon wafer 18 was inserted into a wafer insertion groove 19 in a cassette board 17. The grooves 19 were formed by laser beam machining as described above. The board was set in a mother board 21 to which silicon plates 22 were anchored with engaging pins 20, as shown in Fig. 7. Then, the mother board was carried into the furnace tube 23 of an electric furnace having a liner tube 24 and the furnace tube 25, as shown in Fig. 9. The wafers were oxidized. Uniform and good-quality oxide film was formed on the obtained silicon wafers. The total weight of the cassette board was substantially equal to the weight of the mother board.

#### **Example 3**

The round rod of Example 2 was used. As shown in Fig. 10, a silicon wafer resting member 17 was connected to a base member 21 via a silicon plate 22. The assembly was transported into a vertical electric furnace 25 shown in Fig. 10. Annealing was performed in the same way as in Example 3. As a result, the silicon wafer resting member was not contaminated with sodium element. The weight of the wafer resting member was about half the weight of the base member.

The above-described combinational jig consists of a silicon wafer resting member and a member for supporting the wafer resting member. During the fabrication of the combinational jig, each jig is annealed in a commercially available annealing furnace lined with alumina. Silicon bases are laid on desired portions on the floor of the furnace. Desired performance can be derived by adopting this industrially straightforward method.

**Effects of the Invention**

By forming the resting grooves by laser beam machining no microcrack on the wafer resting members of a quartz glass jig for heat treating silicon semiconductor devices occurs and contamination by impurities is prevented and thus favorable heat-treatment of the silicon semiconductor devices is performed when the jig is used.

By using a silicon member for the novel combinational jig for heat treatment of silicon wafers contamination of silicon wafers, especially contamination due to movement of sodium element can also be prevented effectively. Thus, the combinational jig offers high-quality silicon wafers.

**QUARTZ GLASS JIG FOR THE HEAT TREATMENT OF SILICON  
WAFERS AND METHOD AND DEVICE FOR PRODUCING SAME**

**Claims:**

1. A quartz glass jig for heat treatment of silicon wafers comprising a silicon wafer resting member, having a quartz glass board in and along which wafer resting grooves are formed, characterized in that the wafer resting grooves are formed by laser beam machining.
2. A quartz glass jig as set forth in claim 1, characterized in that the portion within 2 cm of the contact point with a wafer in the neighborhood of each of the wafer resting grooves are processed by laser beam machining.
3. A quartz glass jig as set forth in claim 1, characterized in that the surface region of at least 30  $\mu\text{m}$  in depth of each of quartz glass parts constructing the quartz glass jig for heat treatment of silicon wafers has a iron-concentration of 0.4 wt.-ppm or less, a sodium-concentration of 0.4 wt.-ppm or less, a potassium-concentration of 0.2 wt.-ppm or less and a calcium-concentration of 0.8 wt.-ppm or less, all on the average.
4. A quartz glass jig as set forth in claim 1, characterized in that quartz glass board is welded integrally with and supported by a supporting member.
5. A quartz glass jig as set forth in claim 4, characterized in that the quartz glass board is produced by extrusion molding of high purity silicon dioxide molten in a crucible.

6. A quartz glass jig for heat treatment of silicon wafers, comprising a resting member on which the silicon wafers are placed and a base member for supporting the resting member, characterized in that both resting member and base member being combined together via a silicon member.
7. A quartz glass jig as set forth in claim 6, wherein the quartz glass forming the resting member contains less than 0.2 wt.-ppm iron, and wherein the quartz glass forming the base member contains 5-20 wt.-ppm aluminum, less than 0.1 wt.-ppm lithium, and less than 0.1 wt.-ppm sodium.
8. A method of fabricating a combinational jig for heat treatment of silicon wafers according to claim 6, comprising the steps of:
  - forming a silicon wafer resting member from a quartz glass containing less than 0.2 wt.-ppm iron;
  - forming a base member by glass blowing from a quartz glass containing 5-20 wt.-ppm aluminum, less than 0.1 wt.-ppm lithium, and less than 0.1 wt.-ppm sodium; and
  - annealing these jigs,the improvement wherein the annealing step is carried out on silicon bases.
9. An annealing furnace for fabrication of a combinational jig for heat treatment of silicon wafers according to claim 6, the furnace having a furnace floor on which silicon bases are positioned.

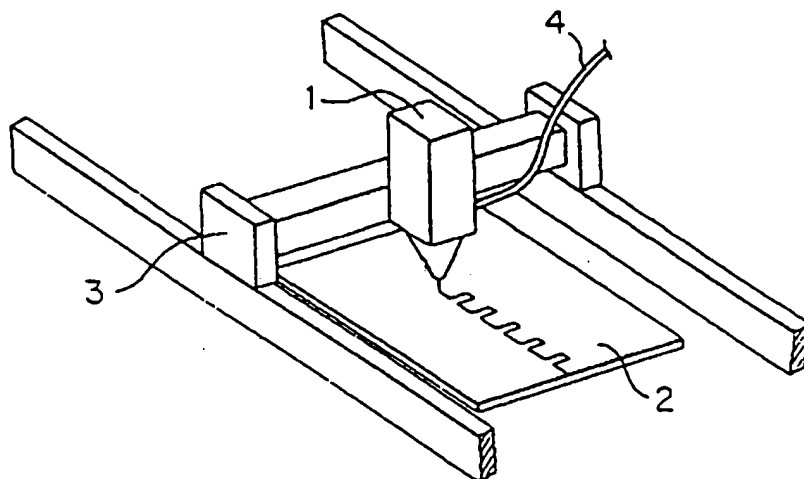


Fig. 1

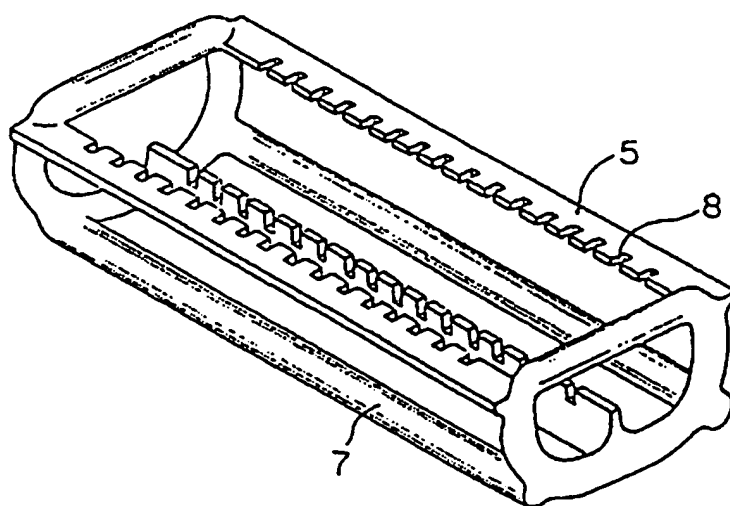


Fig. 2

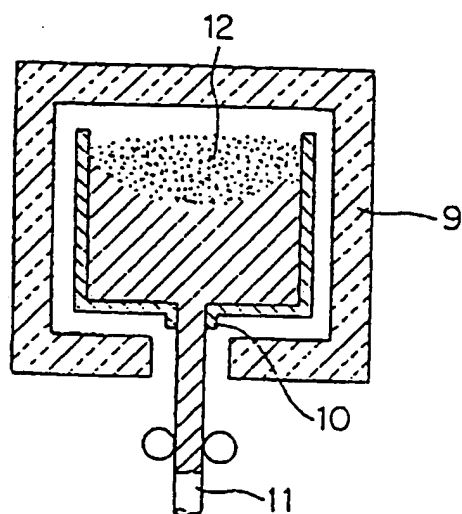


Fig. 3

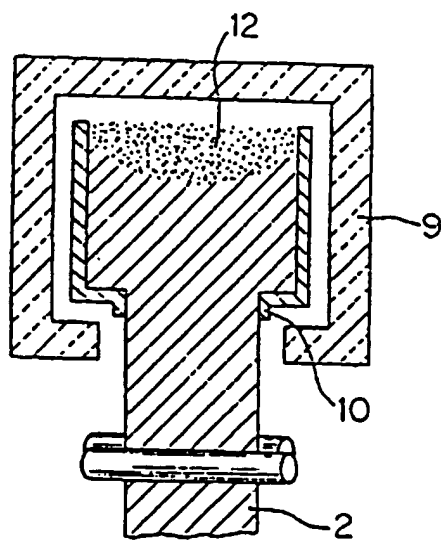


Fig. 4

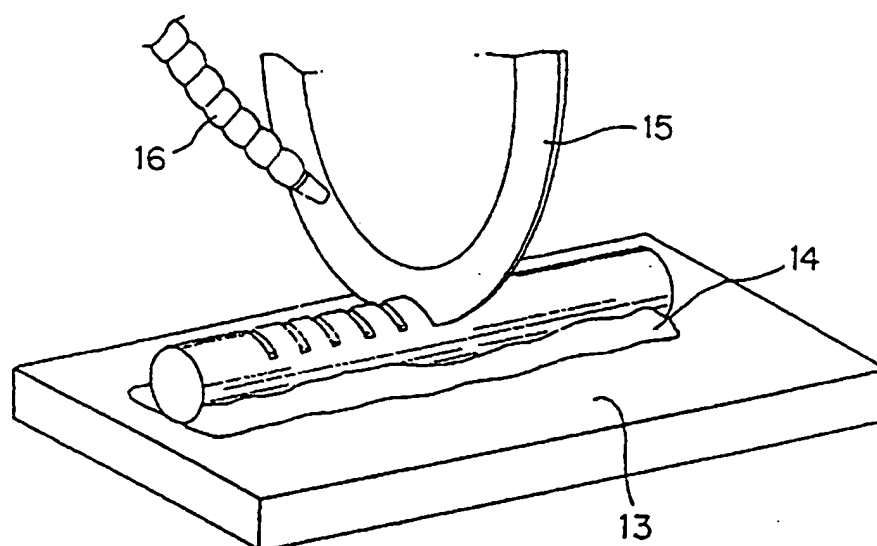


Fig. 5



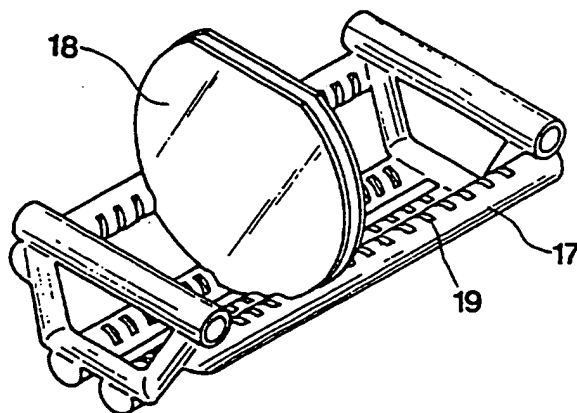


Fig. 6

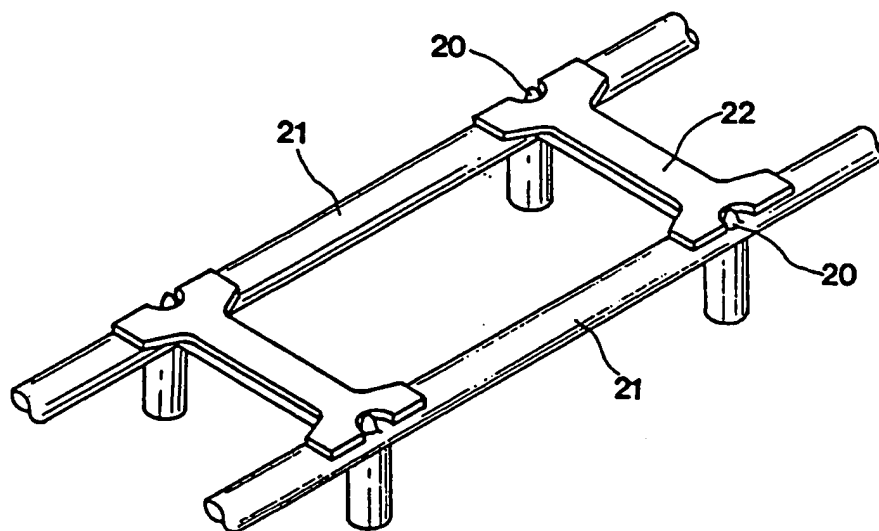


Fig. 7

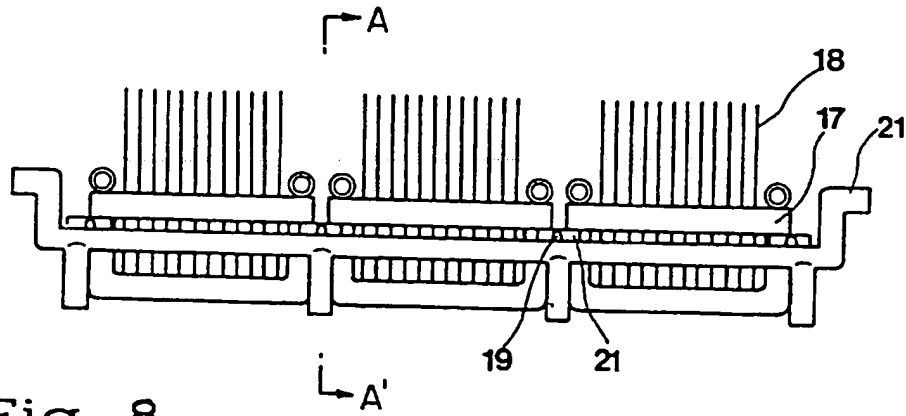


Fig. 8

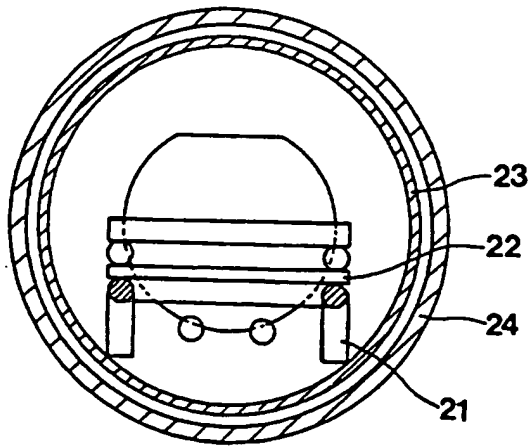


Fig. 9

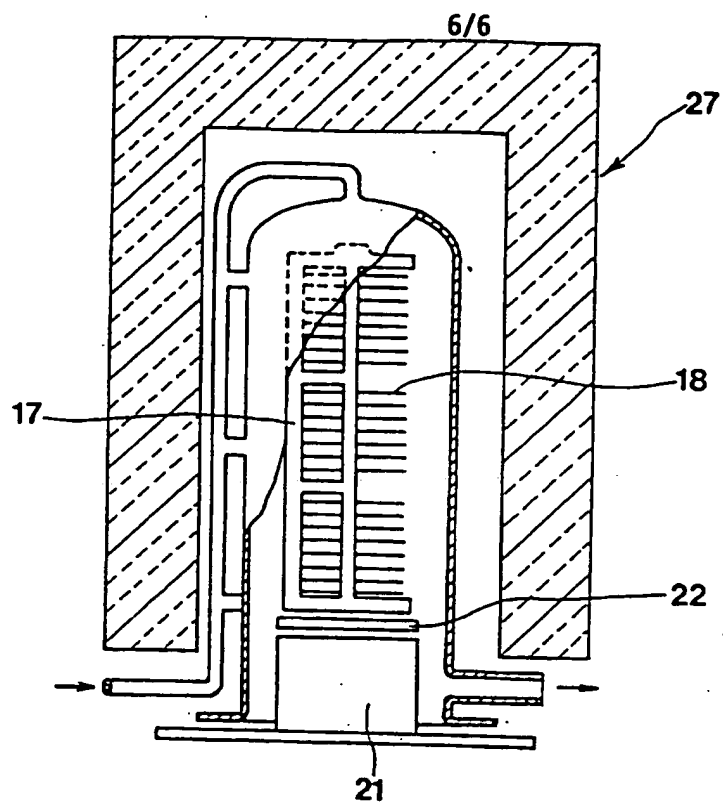


Fig. 10

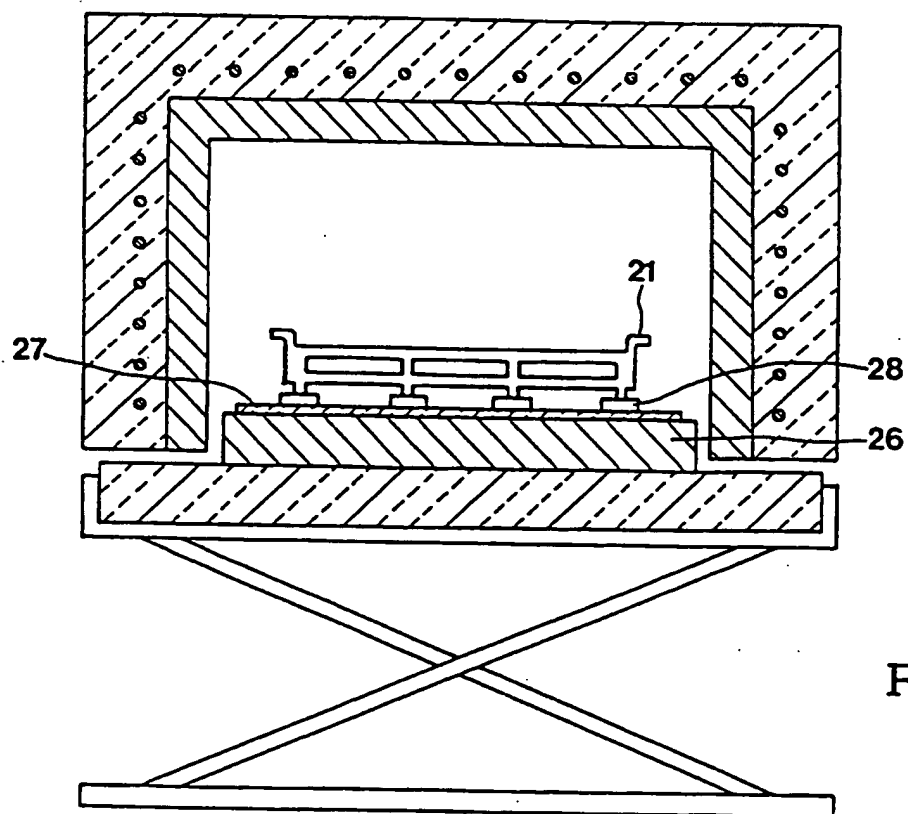


Fig. 11